FRONT SHEET

Title:
Childhood and adolescent psychopathology and subsequent tobacco smoking in young adults: Findings from an Australian birth cohort

List of authors:
Jane A. Fischer, Jackob M. Najman, Gail M. Williams and Alexandra M. Clavarino

Authors' affiliations and addresses:
Jane A. Fischer, School of Pharmacy, Pharmacy Australia Centre for Excellence (PACE), The University of Queensland, Brisbane, Australia. Address: Pharmacy Australia Centre for Excellence (PACE), The University of Queensland, Woolloongabba, Queensland, 4102, Australia. Email: Jane_Fischer@health.qld.gov.au.

Jackob M. Najman, Schools of Population Health and Social Sciences, The University of Queensland, Brisbane, Australia. Address: Queensland Alcohol and Drug Research and Education Centre, Level 1, Public Health Building, The University of Queensland, Herston Road, Herston, Queensland, 4006, Australia. Email: J.Najman@uq.edu.au.

Gail M. Williams, School of Population Health. The University of Queensland, Brisbane, Australia. Address: School of Population Health, The University of Queensland, Herston Road, Herston, Queensland, 4006, Australia. Email: G.Williams@uq.edu.au.

Alexandra M. Clavarino**,** School of Pharmacy, Pharmacy Australia Centre for Excellence (PACE), The University of Queensland, Brisbane, Australia. Address: Address: Pharmacy Australia Centre for Excellence (PACE), The University of Queensland, Woolloongabba, Queensland, 4102, Australia Email: A.Clavarino@uq.edu.au.

Conflict of interest statement
No researcher has any connection with the tobacco industry or any body substantially funded by these organisations. The core study was funded by the National Health and Medical Research Council (NHMRC), Australia, but the views expressed in the paper are those of the authors and not necessarily those of any funding body.

Running head:
Predictors of young adults tobacco smoking

Key words:
tobacco smoking, children, adolescence, psychopathology, prospective birth cohort

Word count:
3159

ABSTRACT

Aims: To examine whether child and adolescent psychopathology predicts subsequent tobacco use at 14 and 21 years of age.

Design: Prospective birth cohort study.

Setting: Data is taken from the Mater Misericordiae Hospital and University of Queensland Study of Pregnancy and its outcomes (MUSP), a prospective longitudinal study which recruited women at their first antenatal visit in Brisbane, Australia.

Participants: A five, 14 and 21 years follow-up of children whose mother's were recruited into the MUSP birth cohort study at their first antenatal visit.

Measurements: Psychopathology exposure was measured using the Achenbach's Child Behaviour Checklist (CBCL) at five years, the Youth Self Report (YSR) at 14 years and the Young Adult Self Report (YASR) at 21 years. Outcome measures were the children's tobacco smoking status at the 14 and 21 years follow-up and the Composite International Diagnostic Interview (CIDI) based DSM-IV nicotine dependence at 21 years follow-up.

Findings: Externalizing symptoms had the strongest association with subsequent tobacco use. Children who met the criteria for CBCL aggression at 5 years were more likely to be tobacco smokers at the 14 year follow-up. YSR externalizing behaviours at the 14 year follow-up predicted tobacco smoking, but not DSM-IV nicotine dependence at the 21 year follow-up. Internalizing behaviour (anxiety/depression) was associated with a reduced rate of smoking at the 14 and 21 year follow-ups but externalizing behaviour and attention problems at 14 and 21 years were separately and cumulatively associated with nicotine dependence at the 21 year follow-up.

Conclusion: Childhood and adolescent psychopathology predict tobacco smoking, but some forms of psychopathology predict increased (aggression/delinquency; attention problems) and other forms decreased (anxiety/depression) smoking. There may be some benefits in targeting children with early onset aggressive/delinquent behaviour problems with tobacco smoking prevention initiatives.

This is a post-print version of the following article: Fischer, Jane A., Najman, Jackob M., Williams, Gail M. and Clavarino, Alexandra M. (2012) Childhood and adolescent psychopathology and subsequent tobacco smoking in young adults: findings from an Australian birth cohort. *Addiction, 107* 9: 1669-1676. © Wiley

INTRODUCTION

There is consistent evidence for an association between tobacco smoking and mental illness [1-5], particularly depression [6-12] and anxiety [1, 2]. Smoking is associated with higher rates of anxiety and affective disorders, with current smokers reporting greater psychological distress and mental illness diagnoses than non-smokers [2]. There is also a possibility that the association between psychopathology and tobacco smoking may change as the proportion of smokers in the population declines. With less than 20% of the Australian population now smokers [15, 16] it may be that the remaining tobacco smokers are more likely to have symptoms of psychological distress.

The temporal sequence between tobacco smoking and psychopathology in adolescents and young adults continues to be a matter of dispute [13, 17, 18]. Three causal pathways are possible. Tobacco smoking might precipitate a mental illness; mental illness might lead to tobacco smoking; or the association might be due to other factors, that is, confounders which lead to both tobacco smoking and mental illness. There is evidence supporting the plausibility of each of the three alternative temporal pathways.

A number of studies have suggested that tobacco smoking precedes depression [19-24]. For example, Wu and Anthony (1999) found that tobacco smoking was associated with a subsequent increase in the risk of depression in a prospective population based study of 1,731 youth. Other studies have found that depression precedes tobacco smoking [18, 25-29]. For example Fergusson et al (2003) found depression at 16 years was associated with daily tobacco smoking and nicotine dependence at 21 years.

There may be common pathways to tobacco smoking and mental illness [3, 4] or it may be bi-directional [5] A range of possible confounders have been identified [21, 23, 26, 27, 31-35]. Key social and demographic variables which have been shown to predict both tobacco smoking and mental illness are poverty [6] and marital breakdown [7]. Whilst hostility and aggression type behaviours have also been implicated [23, 33, 38] they can also be conceptualised as evidence of psychopathology as reflected in such measures as the Achenbach Child Behaviour Checklist (CBCL) [8] and the impulse control disorders in the Composite International Diagnostic Interview [9].

The present study aims to extend previous research intended to determine the temporal sequence between tobacco smoking and mental illness. It uses data from a prospective birth cohort to examine whether early life internalizing (anxiety and depression), externalizing (aggressive/delinquent) and attention problems predict tobacco smoking. The study also includes a number of variables which might confound the relationship between tobacco smoking and mental illness.

METHODS

Participants

Data for this study is taken from Mater Misericordiae Hospital and University of Queensland Study of Pregnancy and its outcomes (MUSP). Between 1981 and 1983, interviewers approached 8,556 women at their first antenatal visit at the Mater Misericordiae Hospital in Brisbane, Australia to participate in the study of which 8,458 (98.9%) agreed. The cohort consists of 7,223 live singleton babies who were not adopted out. This represents 87% of all women who attended the antenatal clinic during the study period [10]. Data is restricted to the offspring for whom information was available at the 21 years follow-up. Some participant's lost to follow-up may subsequently return to the study. Figure 1 details the follow-up cohort.

insert figure one about here

Mothers have been followed-up when the children were 3–5 days old, 6 months old, and then 5, 14 and 21 years later. Their offspring self-completed questionnaires at the 14 and 21 year follow-ups. At the 21 year follow-up the average age of participating offspring was 20.4 years (SD=0.8), 51.0% were female, 24.6% had tertiary education, 54.6% had completed high school and 20.8% had some primary or secondary school education [10]. Response rates were maximized by using a range of strategies. These included obtaining six family/friend contact numbers from participants and searching the electoral (voting) roll for details of any change of address. In Australia voting is compulsory and all persons over 18 years are required to register. Survey administration occurred both over the telephone and face to face.

Ethics clearances for each phase of data collection have been obtained from either or both the Mater Misericordiae Hospital and University of Queensland human research ethics committees.

Instruments

Measurement of Outcomes

Information on tobacco smoking was obtained from the offspring at both the 14 and 21 year follow-ups. At these times the children were asked "which of the following best describes your smoking status now", with response options as follows: I have never smoked, I used to smoke, I now smoke occasionally and I now smoke regularly. This data was recoded into 'smoking' and 'not smoking' at both 14 and 21 years follow-up. "Not smoking" consists of never smokers and former smokers.

At the 21 year follow-up the Composite International Diagnostic Interview (CIDI-Auto) was used to assess nicotine dependence according to DSM-IV diagnostic criteria [11-13]. The CIDI-Auto is a structured diagnostic interview that can produce DSM-IV and ICD-10 diagnoses. The DSM-IV diagnosis of nicotine dependence was used as a measure of outcome. The CIDI-Auto is a fully computerised version of the standard CIDI which can be administered either by an interviewer or completed by the respondent. The CIDI-Auto has good inter-rater reliability, test-retest reliability and acceptable validity [9].

Measurements of exposure

'Internalizing', 'externalizing' and 'attention problems' measures of psychopathology were obtained using the CBCL [14] and Youth Self Report (YSR) [8]. Both instruments consist of standardised checklists for child and adolescent behaviour problems and competencies [8, 14, 15]. The internalizing measures used include internalizing at 5 years and anxious/depressed symptoms at 14 years and 21 years. The externalizing measure includes aggression at 5 years and externalizing at 14 years and 21 years. The attention problems measure used includes social/attention/thought problems (of which five of the ten are measures of attention) at 5 years and attention problems at 14 and 21 years [39, 45, 47].

A modified (short form) of the CBCL was completed by mothers at five years. It included 33 of the 113 items from the original scale. Items selected assessed the most commonly

occurring behaviours in five year olds. Mothers rated items as occurring 'often', 'sometimes' or 'never', rather than on a three point scale ranging from 0 'not true', 2 'very true' or 3'often true' as described in the original scale. Factor analyses and reliability estimates of sub-scales produced results consistent with Achenbach's data [39, 48]. In addition, a sample of 76 parents whose six year old children were at school also completed the long form of the CBCL. There were very strong correlations (externalising r =0.94, internalising r = 0.89) between the short and full forms of the CBCL [16].

At the 14 years follow-up the YSR was self-completed by the offspring. The YSR has been shown to be reliable and provides arguably valid indicators of problem behaviour [8, 14, 17]. In this study the complete A-D scale (Cronbach's α = 0.84) and T-P scale (Cronbach's α = 0.94) were used and respondents were given the modified options of 'often', 'sometimes', 'rarely' and 'never' at the 14 years follow-up.

Measurements of potential confounders

Child and maternal characteristics potentially relating to child and adolescent mental health and tobacco smoking were included as confounders in the analysis. Potential child confounding and mediating factors included were: gender (measured as either male or female), 'other' psychopathology (internalizing, externalizing, attention problems) and poverty [6, 18, 19]. The poverty measure was created by averaging income data collected up to the five years follow-up and consists of three levels: 'consistent poverty', 'mid-income' and 'consistent mid to high income'. Mothers were asked about their total gross annual household income (including spouse's income, child endowment, etc.) during pregnancy (average ¼ 18 weeks gestation), when the child was 6 months, 5 years, and 14 years old. There were seven discrete income categories as response options (listed in weekly and annual amounts). At each phase family income was classified into two categories with the 25 percentile being the cut-off for low income. A composite variable was created by adding the number of times the family experienced poverty.

Potential maternal confounding factors included were smoking [20-22], anxiety and depression [23] and partner changes [7]. Measures of these were taken from the mothers' data at the 5 and 14 years follow-up. At each time period mothers' responses to whether they

smoked were coded into ‘smoking’ or ‘not smoking’. Maternal anxiety and depression were measured using the Delusions-Symptoms-States-Inventory (DSSI) [24, 25]. In this study the Cronbach’s α coefficient at 5 years follow-up was 0.835 for anxiety and 0.856 for depression; and at 14 years follow-up the Cronbach’s α coefficient was 0.845 for anxiety and 0.877 for depression. Categorical variables for anxiety and depression were then created with ‘nil’, ‘some symptoms’ and ‘many symptoms’. Maternal marital status changes were obtained at two points in time, at 5 years follow-up and at the 14 years follow-up. At both data collection time points, new variables were also created of ‘nil partner change’, ‘one’ and ‘two plus partner changes’.

Statistical analyses

Analysis is restricted to children who could be located at all three time periods and for whom there was data on tobacco smoking status at 14 and 21 years of age. Unadjusted results are presented along with adjustment for (1) psychopathology exposures (ie internalizing, externalizing, attention problems) and (2) selected child and maternal characteristics, as described above. The 90th percentile served as the cutoff for psychopathology exposure, a cutoff mentioned by Achenbach for research purposes [26].

The a priori hypothesis was that there is an association between prior psychopathology and tobacco smoking. Analysis of predictors of smoking at age 14 was carried out using a modified Poisson regression approach [27] to obtain estimates of relative risk associated with a behaviour problem at age 5 and 14 , after adjusting for other behaviour problems at the same time, and then adjusting for potential confounding variables. Repeated measures Poisson models, using generalised estimating equations (GEE), were used to obtain relative risks for behaviour at ages 5, 14 and 21 and smoking at 21. Finally the Poisson model was used to analyse nicotine dependence at age 21, with a similar process for adjustments for other behaviour and covariates.

RESULTS

Table one presents child behaviour psychopathology at 5 and 14 years and the relative risk of tobacco smoking at the 14 years follow-up. Children who met the criteria for externalizing at the 5 year and 14 year follow-up were more likely to be smokers at the 14 year follow-up.

The very strong association between externalising behaviour at 14 years and smoking at 14 years emphasises the degree to which it is proximate externalising behaviour that is important in the onset of smoking. This association remained after adjustment for the other psychopathology and potential confounders. Curiously internalizing behaviours at 5 years were associated with a reduced rate of smoking at 14 years after adjustment for other psychopathology and potential confounders. There was a weaker association between attention problems at the 14 year follow-up and smoking at that same age.

insert table one about here

Table two provides details of the association between psychopathology over the early life course and tobacco smoking at the 21 year follow-up. Internalising behaviour (anxiety/depression) at the 14 year follow-up independently predicts subsequent smoking, with those anxious/depressed at the 14 year follow-up least likely to become smokers. By contrast, externalising behaviour at the 5 year follow-up and the 21 year follow-up was associated with an increased rate of smoking behaviour at the 21 year follow-up. Attention problems at the 14 year follow-up also predicted subsequent smoking, but the association is best characterised as statistically significant but weak. Overall, while there were some early life predictors of smoking, none were very strong and the association with internalising behaviour was an inverse association while the externalising and attention problems association were in the positive direction.

insert table two about here

Table three examines the extent to which psychopathology is associated with nicotine dependence at the 21 year follow-up. Internalizing behaviour does not predict, nor does it appear to be associated with, the diagnosis of ever having experienced a nicotine disorder. Externalising behaviour is associated with a diagnosis of nicotine disorder but only if the externalising behaviour is measured at the 21 year follow-up. This is a strong association. Finally, attention problems at 14 years and 21 years both predict the diagnosis of nicotine disorder by the 21 year follow-up. These are strong associations.

insert table three about here

DISCUSSION

In this study, three early life course predictors of subsequent tobacco smoking and nicotine dependence, internalizing (anxiety/depression), externalizing (aggression/delinquency) and attention problems have been examined. A number of possible covariates have also been accounted for in the analyses. We have found that some psychopathology behaviours predict later onset of tobacco smoking and nicotine dependence in adolescence and young adults, suggesting that some dimensions of mental health predict subsequent tobacco smoking and nicotine dependence.

"Internalising" behaviours are linked to social deficits, expressed as interacting in a submissive and inhibited way, poor interaction with peers, social isolation and low self-concept [28, 29]. Whereas others have concluded that depression is positively associated with tobacco smoking [30-35] this study found that internalizing (anxiety/depression) behaviours were associated with a reduced likelihood of the subsequent uptake of tobacco smoking in children and adolescents, but only after adjustment for other measures of psychopathology.

"Externalising" behaviours are linked with social aggression, disruptive behaviour, a perceived lack of constraint [36] and risky behaviours [37, 38]. Consistent with other studies, our study found that that externalizing behaviour predicts tobacco smoking [37, 39-41]. Moolchan et al [42] also found that higher CBCL externalizing behaviour scores are associated with the later onset of smoking initiation and may also increase the tobacco dependence severity. Leff et al (2003) in a sample of 'youths at risk" found that externalizing behavioural symptoms was associated with age of tobacco initiation. Ferdinand et al (2001) in prospective follow-up study of 10-14 year olds (N=787) from the Dutch general population found that higher YSR delinquent behaviour scores predicted later tobacco smoking.

"Attention" problems is a "mixed syndrome" of social problems, attention problems and thought problems related to both externalizing and internalizing symptoms [43, 44]. After adjustment for covariates, attention problems were associated with tobacco smoking but it was more apparent with nicotine dependence both in adolescence and in young adulthood.

The strongest associations were for externalizing, attention problems and nicotine dependence at the 21 year follow-up. This cumulative effect may be bi-directional [5]. Nicotine dependence and psychopathology may reinforce each other, worsening both conditions. The co-occurrences of externalizing and nicotine dependence and of attention problems and nicotine dependence at the 21 years follow-up, suggests common underlying core psychopathological processes are involved [45, 46]. This is biologically plausible. Externalizing disorders have been found to co-occur with alcohol and other drugs misuse [47, 48] and attention problems are a mixed syndrome. Research is required on how and why this may occur [49] and its implications for prevention in at risk children and adolescents.

This study has several strengths. Firstly the data are from a longitudinal study that prospectively recruited participants during the antenatal period. This has enabled key aspects of participant lives to be measured prior to the onset of smoking behaviour. Secondly standard measures were used, such as the CIDI-Auto to measure nicotine dependence.

In this study we have used Generalised Estimating Equations (GEE). GEE has several benefits for longitudinal research. Firstly it accounts for missing observations, so that all participants are always nominally included in the analysis [51]. A further challenge in longitudinal studies is accounting for 'time'. In particular the difficulty in including the timing of indicator events in relation to changes in diagnostic status [52].

There are potentially several limitations to the study. CBCL responses at five years follow-up were provided by the participant's mothers and are based on her perceptions of their child's behaviours. However the CBCL as administered to mothers and significant others in a child's life is considered to be reliable measures of childhood psychopathology [43]. Although this study used a modified CBCL at five years follow-up, this measure was found to have good reliability and internal consistency. Data was not collected on paternal smoking.

Loss to follow-up is a consistent problem with cohort studies. At the 21 year follow-up, 53% of the original birth cohort participated. While attrition is high at the 5, 14 and 21 year follow-ups, a great deal is known about the characteristics of those lost to the study. Complete data

are available from recruitment and from after the child's birth [50]. In this study children lost to follow-up were more likely to be from families with low income at birth, to have mothers who smoked tobacco throughout their pregnancy and to have parents with low educational attainment [21]. Najman et al (2008) has previously examined participant drop out by 21 years, and found that that participants with higher CBCL total problem scores at age 5 years and higher anxiety/depression scores on the YSR at age 14 years, were more likely to be lost to follow-up by 21 years ($p < 0.05$). However, the results from sensitivity analyses based on these factors, including inverse probability weighting, did not differ from the unweighted analyses, suggesting that selection bias does not substantially affect study results [10]. As participants lost to follow-up may have worse health profiles, the estimates of the strength of the relationships found is likely to be conservative [50].

In this study tobacco smoking prevalence at the 14 year follow-up (1995-1997) was 11.68% in the last week. At the 21 year follow-up (2001-2004) some 36.24% of the cohort reported having ever smoked tobacco. Data from the Cancer Council Victoria, which is the most detailed and consistently available [51]can contextualise this finding. The prevalence of tobacco smoking in the last week amongst 14 year olds in 1996 was 20-24%. Our study found a much lower rate of tobacco use by 14 year olds. It is possible that some respondents may have completed their questionnaires in a context where they may have been concerned that their mother may have seen some of their answers. It seems plausible that we have an underestimate of the percent of smokers at 14 years of age. The prevalence of having ever smoked tobacco amongst 18-24 year olds in 2001 was 29% and in 2004 it was 27% [51].

Using a prospective longitudinal analysis of an offspring cohort, our findings suggest that some measures of psychological distress (specifically aggression and delinquency) and attention problems predict tobacco smoking. As we found no evidence that anxiety/depression predict subsequent smoking behaviour it suggests that it is smoking which may lead to anxiety/depression. Manifestation of anxiety and depression symptoms in tobacco smokers may be an outcome of smoking. Clearly childhood and adolescent mental health and tobacco smoking are intimately intertwined. Primary prevention efforts targeting the risk of

tobacco smoking amongst children and adolescents with behavioural problems may have some benefits to further reduce the uptake of smoking.

Acknowledgements

We are grateful to all study participants. Mr Greg Shuttlewood, University of Queensland helped with the data management for this study.

REFERENCES

1. Morissette, S., Tull, M., Gulliver, S., Wolfsdorf Kamholz, B., and Zimering, R., Anxiety, anxiety disorders, tobacco use, and nicotine: a critical review of interrelationships. *Psychol Bull* 2007; **133**: 245-72.
2. Degenhardt, L. and Hall, W., The relationship between tobacco use, substance use disorders and mental health: results form the National Survey of Mental Health and Wellbeing. *Nicotine Tob Res* 2001; **3**: 225-34.
3. Breslau, N., Kilbey, M., and Andreski, P., Nicotine dependence and major depression. *Arch Gen Psychiat* 1993; **50**: 31-5.
4. Kendler, K., Neale, M., MacLean, C., Heath, A., Eves, L., and Kessler, R., Smoking and major depression: a causal analysis. *Arch Gen Psychiat* 1993; **50**: 36-43.
5. Griesler, P., Mei-Chen, H., Schafran, C., and Kandel, D., Comorbid psychiatric disorders and nicotine dependence in adolescence. *Addiction* 2011; **106**: 1010-20.
6. De Beyer, J., Lovelace, C., and Yurekli, A., Poverty and Tobacco. *Tob Control* 2001; **10**: 210-1.
7. Hayatbakhsh, M., Najman, J., Jamrozik, K., Mamun, A., and Alati, R., Do parents' marital circumstances predict young adults DSM-IV cannabis use disorders? a prospective study. *Addiction* 2006; **101**: 1778-86.
8. Achenbach, T., *Manual for the Child Behavior Checklist/4-18 and 1991 Profile*. 1991, University of Vermont, Department of Psychiatry: Burlington, VT.
9. Andrews, G. and Peters, L., *The CIDI-Auto: a computerised diagnostic interview for psychiatry*. 2003, St Vincent's Hospital, Sydney, Australia: World Health Organization Collaborating Centre for Mental Health and Substance Abuse.
10. Najman, J.M., Heron, M., Hayatbakhsh, M., Dingle, K., Jamrozik, K., Bor, W., O'Callaghan, M.J., Williams, G.M., Screening in early childhood for risk of later mental health problems: a longitudinal study. *J Psychiatr Res* 2008; **42**: 694-700.
11. American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders DSM-IV*. 4th Edition ed, ed. Task Force for the Handbook on Psychiatric Measures. 1994, Washington DC American Psychiatric Association.
12. Alati, R., Mamun, A., GM., W., O'Callaghan, M., Najman, J., and Bor, W., In utero alcohol exposure and rediction of alcohol disorders in early adulthood: a birth cohort study. *Arch Gen Psychiat* 2006; **63**: 1009-16.
13. Hayatbakhsh, M., Najman, J., Jamrozik, K., Mamun, A., Bor, W., and Alati, R., Adolescent problem behaviours predicting DSM-IV diagnoses of multiple substance use disorder: findings from a prospective birth cohort study. *Soc Psych Psych Epid* 2008; **43**: 356-63.
14. Achenbach, T., *Manual for the Youth Self Report and 1991 Profile*. 1991, University of Vermont, Department of Psychiatry: Burlington, VT.
15. Petty, C., Rosenbaum, J., Hirshfeld-Becker, D., Henin, A., Hubley, S., LaCasse, S., et al., The child behaviour checklist broad-band scales predict subsequent psychopathology: a five year follow-up. *J Anxiety Disord* 2008; **22**: 532-9.
16. Najman, J., Williams, G., Nikles, J., Spense, S., Bor, W., O'Callaghan, M., et al., Bias influencing maternal reports of child behaviour and emotional state. *Soc Psych Psych Epid* 2001; **36**: 186-94.
17. Wiznitzer, M., Verhulst, F., van den Brink, W., Koeter, M., van der Ende, J., Giel, R., et al., Detecting psychopathology in young adults: the Young Adult Self Report, the General Health Questionnaire and the Symptom Checklist as screening instruments. *Acta Psychiatr Scand* 1992; **86**: 32-7.

18. WHO, *Tobacco and Poverty: A Viscious Cycle*. 2004, World Health Organization.
19. Najman, J., Toloo, G., and Siskand, V., Socioeconomic disadvantage and changes in health risk behaviours in Australia: 1989-90 to 2001. *WHO Bull* 2006; **84**: 976-84.
20. O'Callaghan, F., O'Callaghan, M., Najman, J., Williams, G., Bor, W., and Alati, R., Prediction of adolescent smoking from family and social risk factors at 5 years, and maternal smoking in pregnancy and at 5 and 14 years. *Addiction* 2006; **101**: 262-90.
21. Mamun, A.A., O'Callaghan, F.V., Alati, R., O'Callagan, M., Williams, G.M., Najman, J.M., et al., Does maternal smoking during pregnancy predict the smoking patterns of young adult offspring? a birth cohort study. *Tob Control* 2006; **15**: 452-7.
22. Lawlor, D., O'Callaghan, M., Mamum, A., Williams, G., Bor, W., and Najman, J., Early life predictors of adolescent smoking: findings from the Mater University Study of Pregnancy and its Outcomes. *Paediatr Perinat* 2005; **19**: 377-87.
23. Oyserman, D., Bybee, D., and Mowbray, C., Influences of maternal mental illness on psychological outcomes for adolescent children. *J Adolescence* 2002; **25**: 587-602.
24. Bedford, A. and Foulds, G., Validation of the delusions-symptoms-states-inventory. *Brit J Med Psychol* 1977; **50**: 163-71.
25. Bedford, A., Foulds, G., and Sheffield, B., A new personal disturbance scale (DSSI/SAD). *Brit J Soc Clin Psych* 1976; **15**: 387-94.
26. Achenbach, T.M., *Integrative Guide for the 1991 CBCL/4-18, YSR, and TRF Profiles*. 1991, Burlington: Department of Psychiatry, University of Vermont
27. Zou, G., A Modified Poisson Regression Approach to Prospective Studies with Binary Data. *American Journal of Epidemiology* 2004; **159**: 702-6.
28. Strauss, C.C., Forehand, R., Smith, K., and Frame, C., The association between social withdrawal and internalizing problems of children. *J Abnor Child Psych* 1986; **14**: 525-35.
29. Rubin, K.H., *Socially withdrawn children: an "at risk" population?*, in *Children's Peer Relations: Issues in assessment and intervention*, B. Schneider, Rubin, K.H., and Ledingham, J., Editors. 1985, Springer-Verlag: New York. p. 125-40.
30. Brook, J., Schuster, E., and Zhang, C., Cigarette smoking and depressive symptoms: a longitudinal study of adolescents and young adults. *Psychol Rep* 2004; **95**: 159-66.
31. Windle, M. and Windle, R., Depressive symptoms and cigarette smoking among middle adolescents: prospective associations and intrapersonal and interpersonal influences. *J Consult Clin Psych* 2001; **69**: 215-26.
32. Goodman, E. and Capitman, J., Depressive symptoms and cigarette smoking among teens. *Pediatrics* 2000; **106**: 748-55.
33. Wu, L. and Anthony, J., Tobacco smoking and depressed mood in late childhood and early adolescence. *Am J Public Health* 1999; **89**: 1837-40.
34. Patton, G., Carlin, J., Coffey, C., Wolfe, R., Hibbert, M., and Bowes, G., Depression, anxiety and smoking initiation: a prospective study over three years. *Am J Public Health* 1998; **88**: 1518-22.
35. Choi, W., Patten, C., Gillin, J., Kaplan, R., and Pierce, J., Cigarette smoking predicts development of depressive symptoms among US adolescents. *Ann Behav Med* 1997; **19**: 42-50.
36. Strauss, M.A., Measuring Intrafamily Conflict and Violence: the conflict tactics (CT) scales *J Marriage Fam* 1979; **41**: 75-88.
37. Moolchan, E., Frazier, M., Franken, F., and Ernst, M., Adolescents in smoking cessation treatment: relationship between externalizing symptoms, smoking history and outcome. *Psychiatr Res* 2007; **152**: 281-5.

38. Laukannen, E., Shemeikka, S., Notkola, I.L., Koivumaa-Honkanen, H., and Nissinen, A., Externalizing and internalizing problems at school as signs of health-damaging behaviour and incipient marginalization. *Health Promot Int* 2002; **17**: 139-46.
39. Breslau, N. and Johnson, E., Predicting smoking cessation and major depression in nicotine dependent smokers. *Am J Public Health* 2000; **90**: 1122-7.
40. Ferdinand, R., Blum, M., and Verhulst, F., Psychopathology in adolescence predicts substance use in young adulthood. *Addiction* 2001; **98**: 861-70.
41. Leff, M., Moolchan, E., Crockus, B., Spureon, L., Evans, L., London, E., et al., Predictions of smoking initiation among at risk youth: a controlled study. *J Child Adoles Subst* 2003; **13**: 59-75.
42. Wang, Y., *Depressive Symptoms and the onset of smoking in urban adolescents: A prospective Study* 2007.
43. McConaughy, S., Advances in empirically based assessment of children's behavioural and emotional problems. *School Psychol Rev* 1993; **22**: 285-307.
44. Abad, J. and Forns, M., Personality Profile for Adolescents at Risk for Internalising and Externalising Problems. *Psychol Rep* 2008; **103**: 219-30.
45. Krueger, R., Caspi, A., Moffitt, T., and Silva, P., The structure and stability of common mental disorders (DSM-III-R): a longitudinal-epidemiological study *J Abnorm Psychol* 1998; **107**: 216-27.
46. Krueger, R., The structure of common mental disorders *Arch Gen Psychiat* 1999; **56**: 921-6.
47. Krueger, R., Markon, K., Chentsova-Dutton, Y., and D. Goldberg, A Cross-Cultural Study of the Structure of Comorbidity Among Common Psychopathological Syndromes in the General Health Care Setting. *J Abnorm Psychol* 2003; **112**: 437-47.
48. Krueger, R., Markon, K., Patrick, C., and Iacono, W., Externalizing Psychopathology in Adulthood: A dimensional-spectrum conceptualization and its implications for DSM-IV. *J Abnorm Psychol* 2005; **114**: 537-50.
49. Krueger, R. and Markon, K., Reinterpreting comorbidity: a model-based approach to understanding and classifying psychopathology. *Ann R Clinc Psych* 2006; **2**: 111-33.
50. Najman, J.M., Bor, W., O'Callaghan, M., Williams, G.M., Aird, R., and Shuttlewood, G., Cohort Profile: The Mater-University of Queensland Study of Pregnancy (MUSP). *Int J Epidemiol* 2005; **34**: 997-.
51. Scollo, M. and Winstanley, M., *Tobacco in Australia: Facts and Issues*. 2008, Cancer Council Victoria: Melbourne. http://www.tobaccoinaustralia.org.au/
52. Twisk, J.W.R., *Applied Longitudinal Data Analysis for Epidemiology: A Practical Guide*. 2003: Cambridge University Press.
53. Grant, K., Compas, B., Stuhlmacher, A., Thurm, A., McMahon, S., and Halpert, J., Stressors and child and adolescent psychopathology: Moving from markers to mechanisms of risk. *Psychol Bull* 2003; **129**: 447-66.

Figure 1: Overview of recruitment, follow-up monitoring and data collection within the cohort study

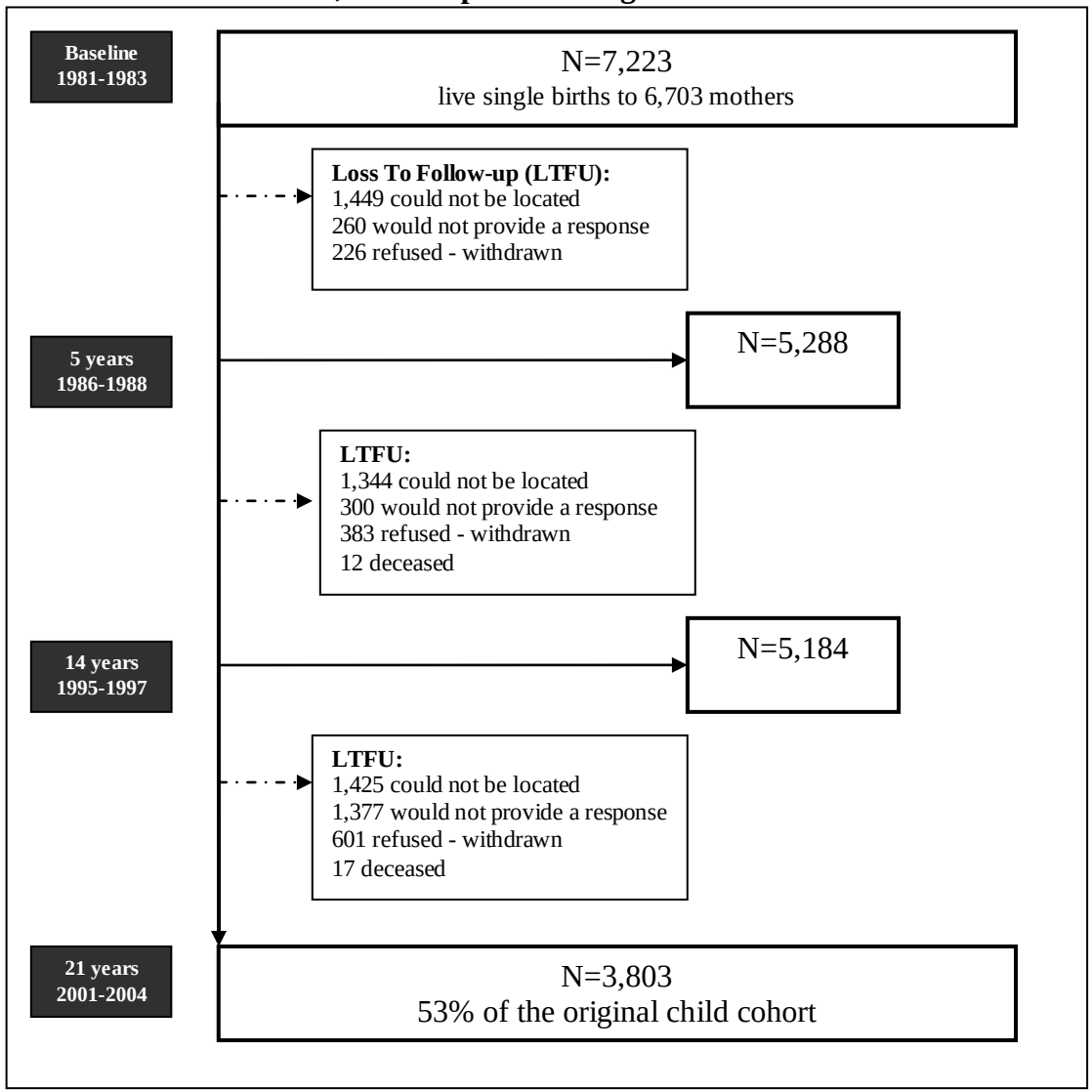

Table 1: Psychopathology at five (CBCL) and 14 (YSR) years and tobacco smoking at 14 years follow-up: RR, 95% CI

Type of psychopathology	Psychopathology					Unadjusted RR (95% CI)	Adjusted[1] RR (95% CI)	Adjusted[2] RR (95% CI)
	Age of Resp	Non-Cases		Cases				
		Number	% Smokers	Number	% Smokers			
Internalising	5	3392	10.7	432	9.7	0.91(0.67,1.23)	**0.70(0.50,0.99)**	**0.70(0.50,0.96)**
	14	3498	9.3	327	24.8	**2.67(2.16,3.32)**	1.19(0.94,1.51)	1.09(0.86,1.37)
Externalising	5	3426	9.9	399	16.5	**1.67(1.31,2.13)**	**1.74(1.32,2.29)**	**1.54(1.17,2.02)**
	14	3444	7.1	381	42.0	**5.90(4.99,6.99)**	**4.85(3.92,5.98)**	**4.06(3.28,5.04)**
Attention Problems	5	3360	10.2	465	13.1	1.28(0.99,1.65)	1.16(0.85,1.58)	1.09(0.80,1.49)
	14	3496	8.7	329	30.7	**3.53(2.91,4.29)**	**1.43(1.12,1.82)**	**1.44(1.14,1.81)**

[1]Adjusted for other psychopathology (internalising, aggression and attention problems) at the same time

[2] Adjusted for other psychopathology (internalising, aggression and attention problems) at the same time, gender, poverty, maternal smoking, depression, anxiety and marital change at 14 years

Table 2: Psychopathology at 5 (CBCL), 14 (YSR) and 21 (YASR) years and tobacco smoking at 21 years follow-up: RR, 95% CI

Type of psychopathology	Psychopathology					**Tobacco Smoking at 21 years**		
	Age of Resp	Non-Cases		Cases		Unadjusted RR (95% CI)	Adjusted[1] RR (95% CI)	Adjusted[2] RR (95% CI)
		Number	% Smokers	Number	% Smokers			
Internalising	5	2425	34.1	301	35.6	1.02(0.87, 1.20)	0.93(0.78, 1.10)	0.91(0.77, 1.08)
	14	2468	33.5	258	41.5	**1.19(1.02, 1.40)**	**0.81(0.68, 0.97)**	**0.77(0.65, 0.92)**
	21	2478	33.5	248	41.9	**1.20(1.02, 1.42)**	0.97(0.81, 1.16)	0.97(0.82, 1.15)
Externalising	5	2444	33.2	282	43.6	**1.19(1.03,1.37)**	**1.20(1.03,1.40)**	**1.19(1.02,1.38)**
	14	2489	32.3	237	55.3	**1.48(1.29,1.69)**	**1.29(1.10,1.51)**	1.15(0.99,1.34)
	21	2495	31.7	231	62.3	**1.77(1.57,2.01)**	**1.70(1.48,1.95)**	**1.61(1.40,1.85)**
Attention Problems	5	2416	33.8	310	38.1	1.06(0.91,1.24)	0.99(0.83,1.17)	0.97(0.82,1.14)
	14	2503	32.4	223	55.1	**1.61(1.41,1.84)**	**1.20(1.01,1.41)**	**1.17(1.00,1.38)**
	21	2428	32.7	298	46.4	**1.31(1.15,1.51)**	1.11(0.95,1.29)	11.16(0.99,1.35)

Adjusted[1:] Adjusted for other psychopathology (internalising, aggression and attention problems) at the same time
Adjusted[2:] Adjusted for other psychopathology (internalising, aggression and attention problems) at the same time, family poverty, maternal smoking, maternal depression and anxiety and marital changes by 14yrs

Table 3: Psychopathology at 5 (CBCL), 14 (YSR) and 21 (YASR) years and nicotine disorder (CIDI) at 21 years follow-up: RR, 95% CI

Type of psychopathology	Psychopathology					**Nicotine Disorder by 21 years**		
	Age of Resp	Non-Cases		Cases		Unadjusted RR (95% CI)	Adjusted[1] RR (95% CI)	Adjusted[2] RR (95% CI)
		Number	% Smokers	Number	% Smokers			
Internalising	5	1516	11.0	176	7.4	0.67(0.39,1.16)	0.65(0.37,1.15)	0.65 (0.37,1.14)
	14	1550	10.5	142	11.3	1.07 (0.66,1.74)	0.83 (0.47,1.46)	0.77 (0.44,1.34)
	21	1556	10.2	136	15.4	1.52 (1.00,2.31)	0.92 (0.60,1.40)	0.83 (0.53,1.29)
Externalising	5	1518	10.3	174	12.6	1.22 (0.81,1.86)	1.51 (0.96,2.38)	1.54 (0.98,2.42)
	14	1596	10.5	96	12.5	1.19(0.69,2.07)	0.89 (0.49,1.64)	0.89 (0.48,1.64)
	21	1565	9.1	127	28.3	**3.10 (2.26,4.26)**	**2.47 (1.70,3.60)**	**2.39(1.61,3.57)**
Attention Problems	5	1513	10.8	179	8.4	0.77 (0.47,1.28)	0.74(0.41,1.31)	0.71 (0.40,1.24)
	14	1580	9.9	112	20.5	**2.08 (1.40,3.08)**	**2.27 (1.43,3.62)**	**2.18(1.36,3.51)**
	21	1514	9.2	178	22.5	**2.45(1.79,3.36)**	**1.83 (1.26,2.66)**	**1.94 (1.33,2.85)**

Adjusted[1:] Adjusted for other psychopathology (internalising, aggression and attention problems) at the same time
Adjusted[2:] Adjusted for other psychopathology (internalising, aggression and attention problems) at the same time, family poverty, maternal smoking, maternal depression and anxiety and marital changes by 14yrs